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3,412,560

JET PROPULSION ENGINE WITH COOLED COMBUSTION CHAMBER, FUEL HEATER, AND INDUCED AIR-FLOW

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ABSTRACT OF THE DISCLOSURE

A jet propulsion engine has a fuel cooled combustion chamber with a chamber outlet nozzle also fuel-cooled. The combustion chamber discharges into a fuel-cooled convergent-divergent jet propulsion nozzle which has an air entry around the combustion chamber. Means are provided for variably admitting ambient boundary layer air into the jet propulsion nozzle. Fuel for combustion is also heated in a heat exchanger disposed between a pre-combustion chamber, in which some fuel is burned, and the main combustion chamber.

My invention is directed to jet engines and particularly to jet propulsion nozzle systems of such engines. In its preferred form, the invention is embodied in a jet propulsion device including a fuel-cooled combustion chamber with variable area outlet means also cooled by fuel, a fuel-cooled convergent-divergent jet propulsion nozzle downstream from the combustion apparatus, and variable means for admitting ambient air to the nozzle adjacent the throat of the convergent-divergent nozzle for induction into the nozzle by the discharge from the combustion chamber. In certain aspects, the invention is particularly suited to engines operating on gaseous fuel.

The principal objects of the invention are to provide an efficient jet propulsion device capable of operation at very high temperatures and suited for operation over a wide spectrum of jet propulsion with respect to altitude and speed of the vehicle in which the device is used. The nature of the invention and the advantages thereof will be clear to those skilled in the art from the succeeding detailed description of the preferred embodiment of the invention and the accompanying drawings thereof.

FIGURE 1 is an elevation view, with parts cut away and in section, of the exhaust end of a jet propulsion engine having provision for fuel heating and fuel burning in the exhaust system.

FIGURE 2 is an enlarged view of a portion of FIGURE 1 illustrating the secondary air inlet doors.

FIGURE 3 is a sectional view taken on the plane indicated in FIGURE 2 showing the arrangement of actuators for the air inlet doors.

FIGURE 4 is a fragmentary cross section through an air inlet door indicated in the plane indicated in FIGURE 2.

FIGURE 5 is a rear elevation view of the discharge end of the exhaust system taken on the plane indicated in FIGURE 1.

FIGURES 6 and 7 are partial sectional views, taken on the planes indicated in FIGURE 5, illustrating the variable combustion chamber outlet means.

FIGURE 8 is a longitudinal sectional view illustrating the cooling arrangement for the convergent-divergent jet nozzle, taken on the plane indicated in FIGURE 5.

FIGURES 9, 10, 11, and 12 are fragmentary sectional views taken on planes indicated on FIGURE 8.

FIGURE 13 is a schematic diagram of an engine showing the principal fuel circuits.

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FIGURE 14 is a somewhat simplified representation of a plug-type variable outlet for the combustion chamber.

Referring first to FIGURES 1 and 13, the engine is enclosed in an outer housing 5 exposed to ambient boundary layer air, such as a fuselage or nacelle. Suitably supported within the housing, as by struts 6, is an annular air duct 7 inside which is mounted a turbine 9 which is preferably of the type described and claimed in my U.S. Patent No. 3,368,794. The turbine drives a compressor 10 which is preferably of the type described and claimed in my U.S. Patent No. 3,365,125. The annular air duct 7 carries combustion air which may be compressed by the ram effect of forward motion of an aircraft, by the compressor, or both, and preferably by both when the aircraft is in rapid motion. This air serves to burn fuel supplied to the engine which is preferably originally a cold liquid and is vaporized in the engine.

The air is supplied first from duct 7 to a precombustion chamber 11 within which a portion of the fuel may be burned, depending upon operating conditions. The air, or air and combustion products, then flows through a cylindrical heat exchanger 13 to which the fuel is supplied from a suitable source by pumping and control means (not illustrated). The heated air flows from the regenerator into combustion chamber 22.

As indicated in FIGURE 13, the fuel may flow from the controlled source through an inlet air cooler 14 which may be bypassed by a valve 15 to the heat exchanger 13 and then through a conduit 17 to the turbine 9 where it expands and is cooled.

The fuel exhausted from the turbine is burned, ordinarily most of it in the combustion chamber 22, although part of it may be burned in the precombustion chamber 11. Before reaching these, however, the turbine exhaust is circulated through a line 18 and the hollow wall of the combustion chamber 22 and through a second inlet air precooler 19 to which fuel is directed through a conduit 20 and returned by way of a conduit 21. A valve 23 provides for bypassing the second inlet cooler to the extent desired.

The combustion chamber 22 discharges through a convergent outlet section into the throat of a convergent-divergent jet propulsion nozzle 25. The area of the combustion chamber outlet is variable as by a ring of movable flaps 26 or an axially movable plug, as will be described in connection with FIGURE 14.

The provision for admission of secondary air to the jet nozzle involves four doors 27 which swing in from a position coincident with the outer wall 5 to the position indicated at the upper part of FIGURE 1 to admit boundary layer air into an annular entry 29 around the combustion chamber 22. Struts 30 support the rear end of the combustion apparatus. The combustion chamber flaps 26 and the secondary air doors 27 may have their position varied over the range from maximum opening to minimum opening in accordance with the operating conditions of the jet propulsion engine and the vehicle. My invention is not concerned with the means for controlling these, but rather with the provision of structure providing for flexibility of operation and including provisions for cooling such that the mechanism is capable of resisting hot combustion gases. The details of the preheating and combustion apparatus also are immaterial to this invention.

Returning to the fuel circuit; as previously pointed out, the fuel after passing through the regenerator, turbine, combustion chamber cooling jacket, and second precooler, is supplied to a line 21. Some of the fuel exhausting from the first precooler bypasses the regenerator, combustion chamber jacket, and second precooler under control of a turbine control valve 28. The total fuel flow is carried